Table 4.26. Normal Concentrations for Copper and Zinc (µg/g dry)

Species	Tissue	Cu	Zn	Reference
Birds - ducks	Liver	44	0	NAS 1980
Birds - fowl	Liver	4.4	0	NAS 1980
Bass	Muscle	0.13	3.6	Förstner and Wittmann 1981, Munn et al. 1995
Carp	Muscle	0.24	10	Förstner and Wittmann 1981
Catfish	Whole Body	3.5	50	Förstner and Wittmann 1981
Fish	Muscle	2	20	Hopkins et al. 1984
Goldfish	Whole Body	3	25	Förstner and Wittmann 1981
Sculpin	Whole Body	0.5	16	Fuhrer et al. 1996
Sucker	Whole Body	0.83	21	Serder 1993
Freshwater bivalves	Whole Body	1.5	70	Förstner and Wittmann 1981
Freshwater crustacea	Whole Body	2.9	40	Förstner and Wittmann 1981
Freshwater gastropods	Whole Body	36	39	Förstner and Wittmann 1981
Caddisfly larvae	Whole Body	3.3	30	Fuhrer et al. 1996
Mammals	Whole Body	0	35	NAS 1980
Mammals - monogastric	Liver	4.4	0	NAS 1980
Mammals - ruminants	Liver	44	0	NAS 1980
Potamogeton	Whole Body	2.0	33	Förstner and Wittmann 1981

deterministic analysis were most-likely values (for example, geomeans or averages) for parameters other than media concentrations and observed maxima from the media files (obtained as described in Section 3.0). Analyses were not performed for contaminants within a segment where no data were above detection limits for either pore water or sediment. Surface water values for segments missing those data were surrogated as described in Section 3.0. Outputs used from the exposure model were equilibrium body burdens; ingestion, inhalation, and dermal doses; and average sediment and/or water concentrations experienced by the various organisms. These values were compared with the toxicological endpoints obtained from the literature as described earlier.

Several segments (11, 18, and 22-27) lacked data on any contaminant concentrations in pore water. An attempt was made to use distribution coefficients (K_d) to estimate pore water from known sediment concentrations in these segments. However, this methodology often overestimates pore water concentrations in sediment (Campbell and Tessier 1996). As shown in Figure 4.11, using the K_d method produced pore water estimates three orders of magnitude greater than those obtained using groundwater

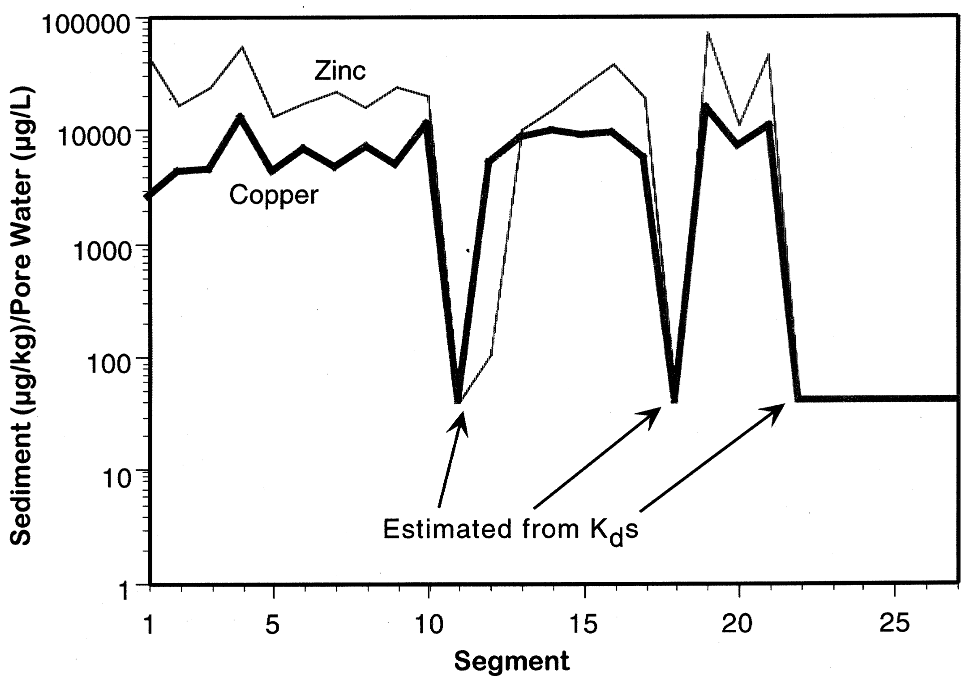

Figure 4.11. Estimated (shown by arrows) and Surrogated (geomean) Pore Water Concentrations for Zinc and Copper in Relation to Known Sediment Concentrations

or seep/spring values. Consequently, pore water concentrations were not estimated using K_d; and Segments 11, 18, and 22-27 were dropped from this assessment due to lack of data. The validity of this action is discussed in Section 4.2.11.

Ingestion exposure was the primary exposure pathway for terrestrial species. In all cases, ingestion exposures for inorganic contaminants were from one to several orders of magnitude greater than exposures via other routes (representative species and contaminants are shown in Figure 4.12). Consequently, daily ingestion exposures were used as the basis for comparison to measurement endpoints in the inorganic chemical EHQs for terrestrial animals. Dermal and ingestion endpoints were used for organics. Doses from all pathways were included in calculating total radiation doses, which were compared with radiological endpoint values, which are given in units of total dose/day. In contrast, toxicological endpoints for non-radiological chemicals are given in terms of water concentrations (aquatic species), or pathway-specific concentrations.

The EHQs (the ratio of estimated exposure dose or concentration to LOEL endpoint values) were computed for river segments and contaminants for each Tier II species. The EHQs that were 1 or greater identified segment-contaminant-species combinations that were evaluated further in the stochastic modeling. EHQs are presented in the "Environmental Hazard Quotients" section of Appendix I-D.

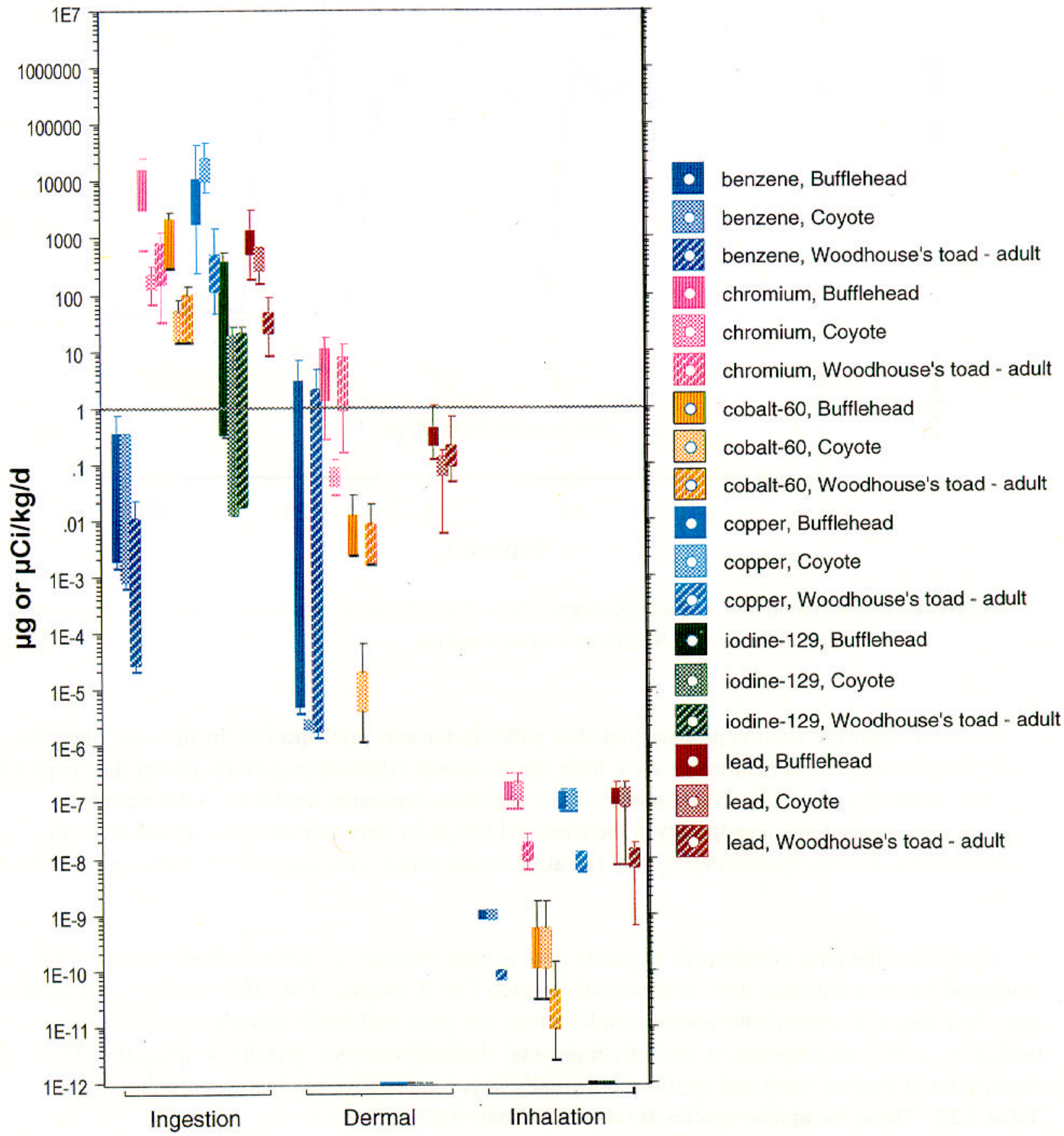

Figure 4.12. Estimated Doses via Ingestion, Inhalation, and Dermal Pathways Obtained from Deterministic Analyses Using Maximum Media Concentration

Summaries of contaminants and locations potentially important to terrestrial species and to aquatic species are shown in Tables 4.27 and 4.28, respectively.

All segments (except 11, 18, and 22-27 where no pore water data were available) contained contaminants that required further evaluation, including Segment 1, which constitutes a reference area. Contaminants contributing to potential risk were ammonia, cesium-137, chromium, cobalt-60, copper, cyanide, europium-154, lead, mercury, nickel, nitrate, strontium-90, uranium-238, and zinc.

Using the stochastic analysis, we identified which species-contaminant-segment combinations pose a nominal risk (0), low risk (1), medium risk (2), and high risk (3). Nominal risk defines combinations where fewer than 25 percent of the simulated exposures exceeded a measurement endpoint. High risk defines combinations where more than 75 percent exceeded a measurement endpoint. Figure 4.13 shows the risk scores for the terrestrial species and Figure 4.14 for the aquatic species.

4.2.9 Stochastic Analyses Using Lognormal Media Data

The exposure model was run in stochastic mode to identify Tier II species that could be at risk from contaminants in the study area, to define where potential risk occurs, and to determine what contaminants are contributing to that risk. The model was set to allow all uncertain parameters in the exposure model to vary according to the distributions previously described. Media concentrations were also allowed to vary as described earlier. The exposure frequency distributions resulting from this analysis represent exposures that could result from a population of animals residing in all portions of the study area segment being evaluated. Part of the spread in the frequency distribution represents stochastic variation in contaminant concentrations and species parameters that is expected in the study area segment. However, much of the variation is also due to uncertainty in species-by-contaminant parameter values.

Outputs used from the exposure model were whole body concentrations (needed for plant endpoints), ingestion doses (needed for terrestrial animal endpoints), and water concentrations (needed for aquatic organism endpoints) experienced by the various organisms. These are the exposure units necessary for comparison with the measurement endpoints obtained from the toxicological literature as described earlier. Measurement endpoints used in this analysis were LOELs and LC_{50}/LD_{50}.

Combinations of species, contaminants, and river segments were classified into four groups based on results of the stochastic simulations: nominal, low, medium, and high potential risk. The categories were based on the proportion of the simulation results that exceeded LC/D_{50} or LOEL endpoints, as shown in Table 4.29. Results of these simulations are presented in the "Risk Categories from Stochastic Modeling" section of Appendix I-D.

Figures 4.13 and 4.14 present the average risk that contaminants in each segment pose to terrestrial and aquatic biota, respectively. The risk scores represent the average percentage of the simulated exposures that exceeded the measurement endpoint (LOELs in upper portion of the figures, LD_{50} or LC_{50} in the lower portions of the figures). Averages were computed only for species that had the potential to be adversely affected by contaminants based on deterministic analyses. These results may describe

Table 4.27. Number of Terrestrial Species for Which the Deterministic EHQ Exceeded 1 (Counts are displayed by river segment, species grouping, and contaminants.)(a)

No. of Species with EHQ>1		Contaminant																				
Segment	Species Category	ammonia	benzene	cesium-137	chromium	cobalt-60	copper	cyanide	europium-152	europium-154	iodine-129	lead	mercury	nickel	nitrate	strontium-90	technetium-99	tritium	uranium-234	uranium-238	xylene	zinc
1	Bird	0	0	0	3	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	10
	Herpetofauna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mammal	0	0	7	0	0	3	0	0	0	0	3	0	0	2	0	0	0	0	0	0	6
	Vegetation	0	0	0	5	0	0	0	0	0	0	4	0	4	0	0	0	0	0	0	0	4
1 Total		0	0	7	8	0	4	0	0	0	0	7	1	4	2	0	0	0	0	0	0	20
2	Bird	0	0	0	7	0	6	0	0	0	0	0	1	0	0	0	0	0	0	0	0	7
	Herpetofauna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mammal	0	0	0	2	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	3
	Vegetation	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
2 Total		0	0	0	14	0	8	0	0	0	0	1	1	0	0	0	0	0	0	0	0	14
3	Bird	0	0	0	3	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	1
	Herpetofauna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mammal	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1
	Vegetation	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
3 Total		0	0	0	8	0	0	0	0	0	0	1	6	0	0	0	0	0	0	0	0	6
4	Bird	0	0	0	6	0	2	0	0	0	0	0	6	0	0	0	0	0	0	0	0	13
	Herpetofauna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	Mammal	0	0	7	0	0	3	1	0	0	0	2	1	0	2	0	0	0	0	0	0	5
	Vegetation	0	0	0	5	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	4
4 Total		0	0	7	11	0	5	1	0	0	0	6	7	0	2	0	0	0	0	0	0	24
5	Bird	0	0	0	5	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	7
	Herpetofauna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mammal	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2
	Vegetation	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
5 Total		0	0	0	10	0	3	0	0	0	0	1	1	0	0	0	0	0	0	0	0	13
6	Bird	0	0	0	1	0	0	0	0	0	0	6	5	0	0	12	0	0	0	0	0	5
	Herpetofauna	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
	Mammal	0	0	0	0	7	0	0	0	0	0	3	1	0	0	6	0	0	0	0	0	0
	Vegetation	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
6 Total		0	0	0	6	7	0	0	0	0	0	10	6	0	0	19	0	0	0	0	0	9
7	Bird	0	0	0	3	0	1	0	0	0	0	0	1	0	0	3	0	0	0	0	0	7
	Herpetofauna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mammal	0	0	7	0	7	3	0	0	0	0	1	0	0	0	1	0	0	0	0	0	3
	Vegetation	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
7 Total		0	0	7	8	7	4	0	0	0	0	1	1	0	0	4	0	0	0	0	0	14
8	Bird	0	0	0	9	0	1	0	0	0	0	0	4	0	0	0	0	0	0	0	0	7
	Herpetofauna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mammal	1	0	7	1	7	3	0	0	0	0	0	0	0	4	0	0	0	0	0	0	3
	Vegetation	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	4
8 Total		1	0	7	18	7	4	0	0	0	0	0	4	0	4	0	5	0	0	0	0	14
9	Bird	0	0	0	5	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	8
	Herpetofauna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mammal	0	0	7	0	7	1	0	0	7	0	3	0	0	0	0	0	0	0	0	0	5
	Vegetation	0	0	0	5	0	0	0	0	0	0	4	0	0	0	0	5	0	0	0	0	4
9 Total		0	0	7	10	7	1	0	0	7	0	7	5	0	0	0	5	0	0	0	0	17
10	Bird	0	0	0	5	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	7
	Herpetofauna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mammal	0	0	7	0	0	3	0	0	7	0	0	0	0	4	0	0	0	0	0	0	4
	Vegetation	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5	0	4
10 Total		0	0	7	10	0	3	0	0	7	0	0	4	0	4	0	5	0	0	5	0	15
12	Bird	0	0	0	3	0	3	0	0	0	0	0	5	0	0	0	0	0	0	0	0	13
	Herpetofauna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
	Mammal	0	0	7	0	7	3	0	0	7	0	3	0	0	1	0	0	0	0	0	0	6
	Vegetation	0	0	0	5	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	5
12 Total		0	0	7	8	7	6	0	0	7	0	7	5	0	1	0	0	0	0	0	0	27
13	Bird	0	0	0	2	1	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	5
	Herpetofauna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mammal	0	0	7	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	Vegetation	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
13 Total		0	0	7	7	8	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	11
14	Bird	0	4	0	3	0	1	0	0	0	0	0	6	0	0	0	0	0	0	0	0	10
	Herpetofauna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mammal	0	0	7	1	0	3	0	0	0	0	3	1	0	3	0	0	0	0	0	0	6
	Vegetation	0	0	0	5	0	0	0	0	0	0	4	4	4	0	0	5	0	0	0	0	4
14 Total		0	0	7	10	0	4	0	0	0	0	7	11	4	3	0	5	0	0	0	0	23
15	Bird	0	0	0	2	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	5
	Herpetofauna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mammal	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	Vegetation	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
15 Total		0	0	7	7	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	11
16	Bird	0	0	0	1	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	6
	Herpetofauna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mammal	0	0	7	0	7	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	5
	Vegetation	0	0	0	5	0	0	0	0	0	0	4	4	4	0	0	0	0	0	0	0	4
16 Total		0	0	7	6	7	2	0	0	0	0	4	12	4	0	0	0	0	0	0	0	15
17	Bird	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	7
	Herpetofauna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mammal	0	0	0	0	0	3	0	0	0	0	3	0	0	3	0	0	0	0	0	0	5
	Vegetation	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
17 Total		0	0	0	5	0	3	0	0	0	0	4	0	0	3	0	0	0	0	0	0	16
19	Bird	0	0	0	7	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	8
	Herpetofauna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mammal	0	0	0	0	0	2	0	0	0	0	1	0	0	3	0	0	0	0	0	0	5
	Vegetation	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
19 Total		0	0	0	12	0	2	0	0	0	0	1	3	0	3	0	0	0	0	0	0	17
20	Bird	0	0	0	2	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	7
	Herpetofauna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mammal	0	0	0	0	0	3	1	0	0	0	1	1	0	3	0	0	0	0	0	0	4
	Vegetation	0	0	0	5	0	0	0	0	0	0	0	0	4	0	0	5	0	0	5	0	4
20 Total		0	0	0	7	0	3	1	0	0	0	1	5	4	3	0	5	0	0	5	0	15
21	Bird	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11
	Herpetofauna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mammal	0	0	0	0	0	3	0	0	0	0	1	0	0	3	0	0	0	0	0	0	5
	Vegetation	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
21 Total		0	0	0	12	0	3	0	0	0	0	1	0	0	3	0	0	0	0	0	0	20

(a) Fungi EHQs were < 1 everywhere for all contaminant, so they are not included in the table.